Exploiting dynamic changes in internal screenhouse climate to inform irrigation in bananas

Shabtai Cohen, Daniel Hadad, Navot Galpaz, Josef Tanny, Yair Israeli, Victor Lukyanov, Ori Achiman, Avishai Londener, Idan Elingold

ARO Volcani Center, Inst. Soil, Water and Env. Sciences

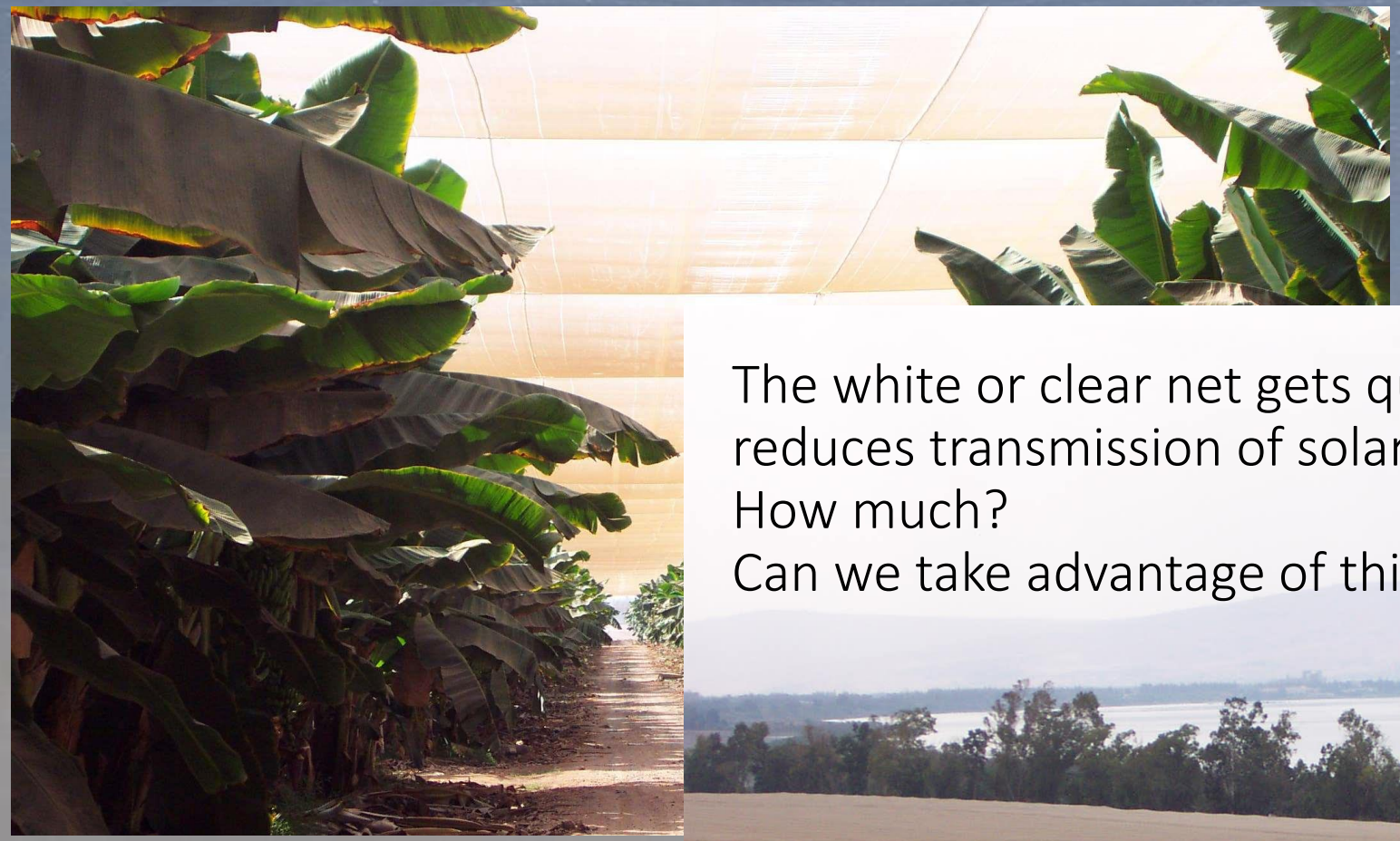
And

Northern R&D, Zemach Research Station

Institute of Soil, Water & Environmental Sciences

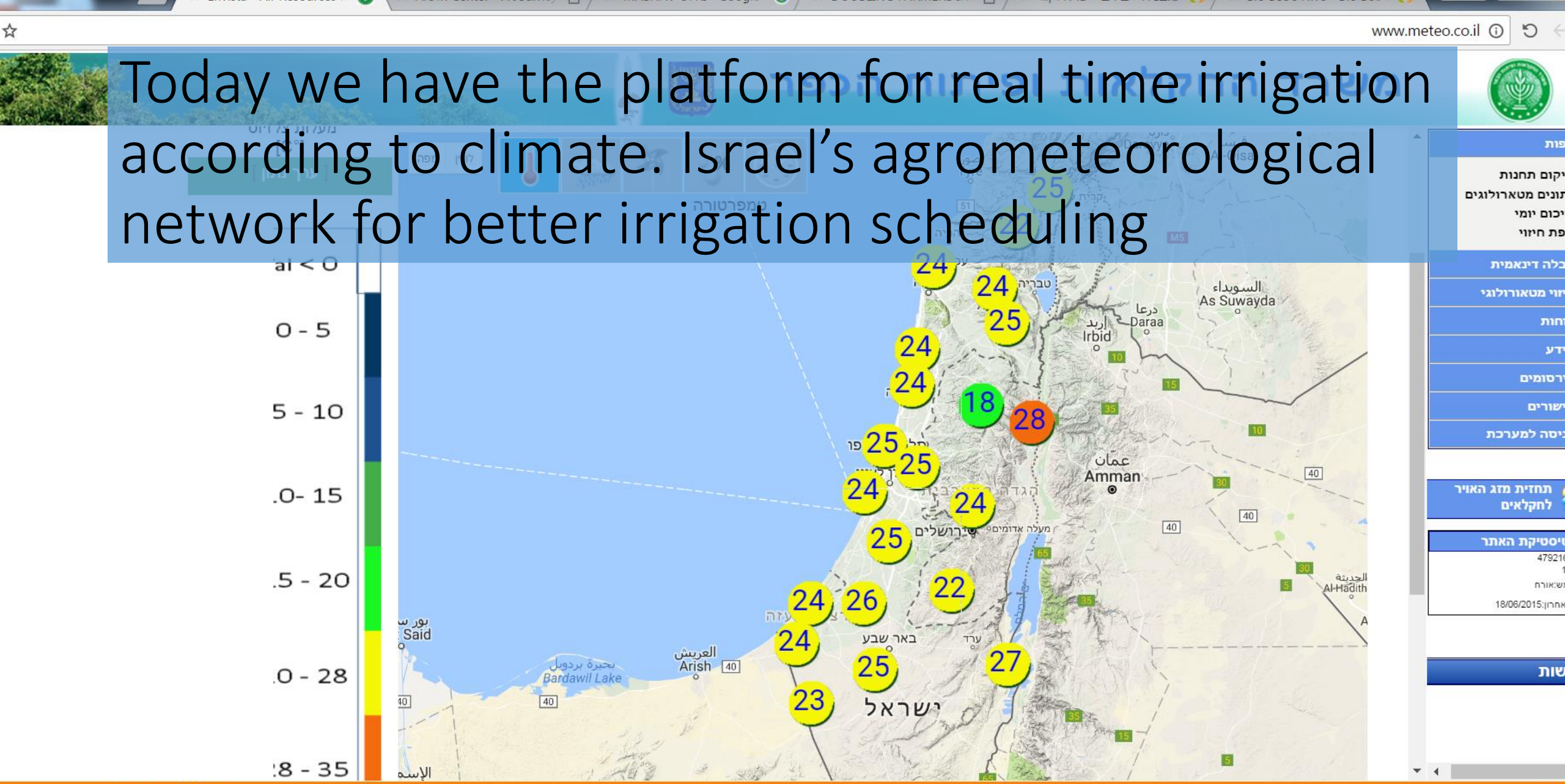
Overview

- The problem – screenhouse climate is coupled to outdoor climate but different. Our previous research produced a fixed ‘screenhouse’ factor for reducing irrigation inside the screenhouse.
- But the relationship between screenhouse and outdoor climate changes during the year, due to dust accumulation on the screen (solar radiation) and growth of the plants inside (wind speed).
- The research focused on irrigation according to measured (monitored) internal climate applied to the Penman-Monteith model for setting irrigation rates.
- Israel already has a platform for supplying farmers with real-time P-M reference ET data. We plan to integrate our measurements into that.



The white or clear net gets quite dirty in the summer, which reduces transmission of solar radiation and water requirements.
How much?
Can we take advantage of this?

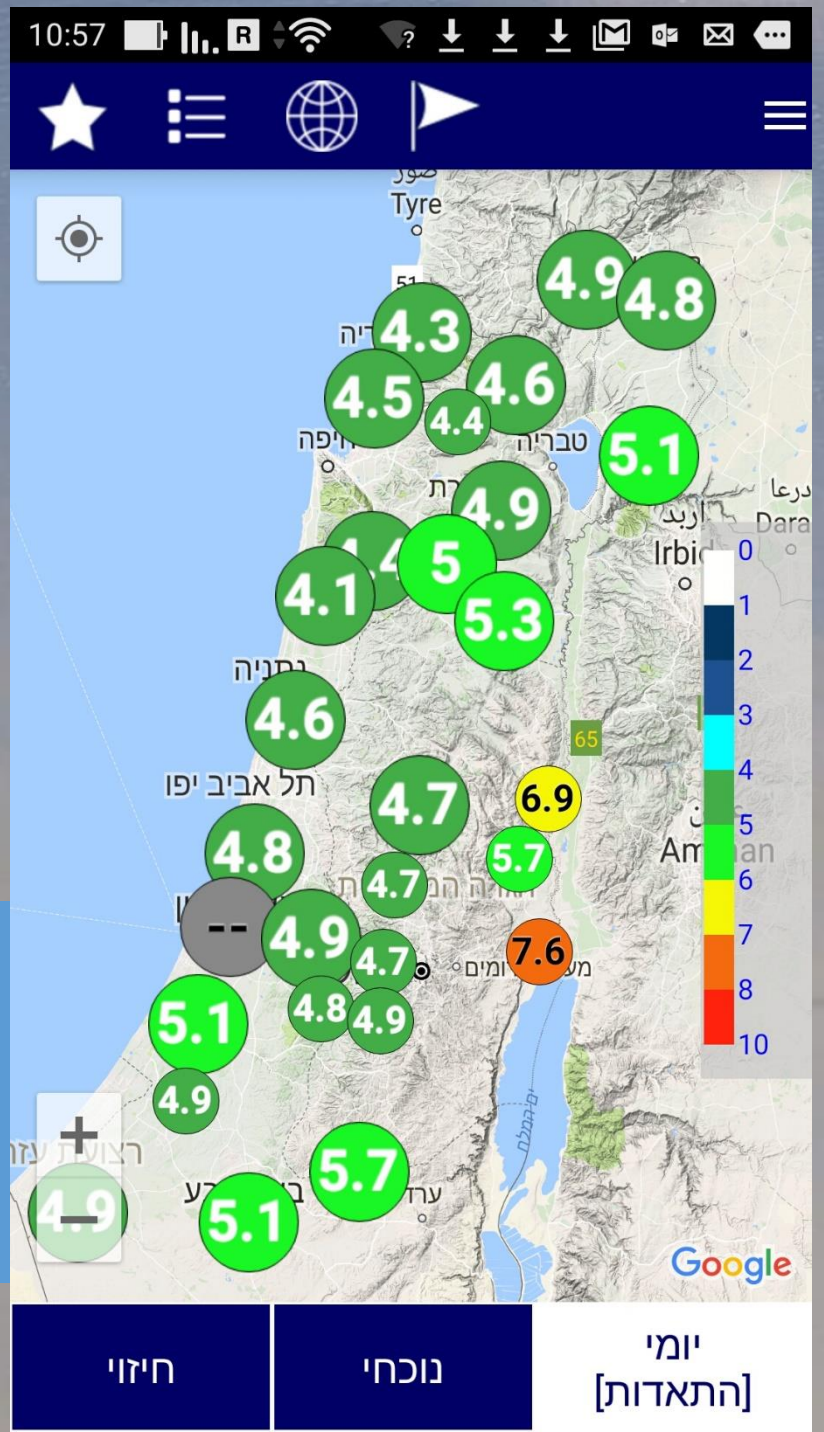
Today we have the platform for real time irrigation according to climate. Israel's agrometeorological network for better irrigation scheduling



Agrometeo

Cellphone App – Real time climate. This screen: Daily ET (mm) for setting irrigation controller

Our first research focused on factors for applying these data for irrigation scheduling in ag structures



FAO 56-Penman-Monteith Equation
Solved using parameters for the screenhouse banana crop

And average daily data

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

+ Wind and radiation relationships

Measured values

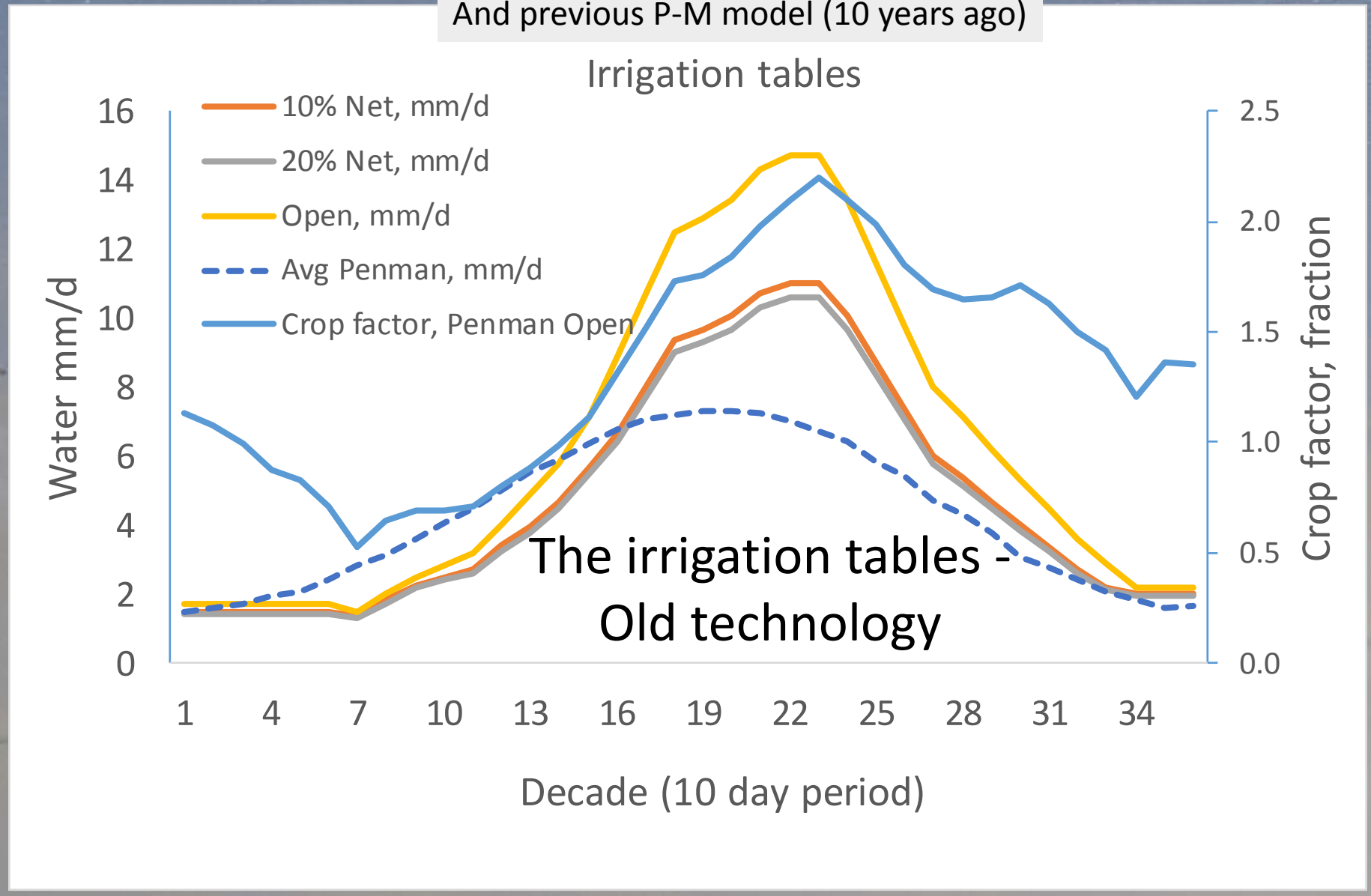
	ET_0	reference evapotranspiration (mm day^{-1})
Solar Radiation	R_n	net radiation at the crop surface (MJ m^{-2} day^{-1})
	G	soil heat flux density (MJ m^{-2} day^{-1})
Air temperature	T	mean daily air temp at 2 m height (°C)
Wind speed	u_2	wind speed at 2 m height (m s^{-1})
	e_s, e_a	saturation and actual vapor pressure (kPa)
Relative humidity	e_s-e_a	vapor pressure deficit, VPD (kPa)
	Δ	Slope of vapor pressure curve (kPa °C^{-1})
	γ	Psychrometric constant (kPa °C^{-1})

The research experiment

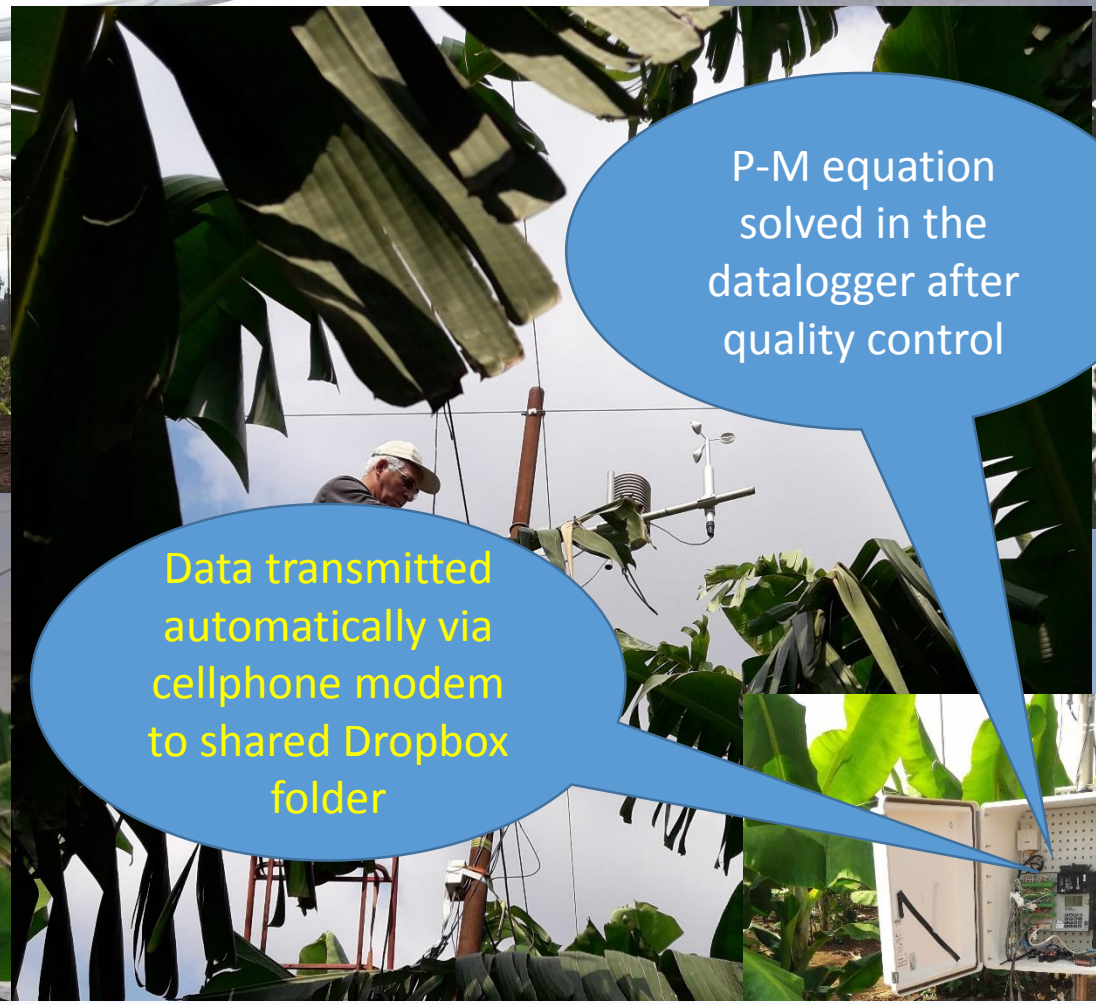
- 5 year field experiment – 3 screenhouses – 10% woven crystal (Leno), 20% woven pearl, and open (not covered) plot. Full banana growth cycle. Began in 2015, now completing 4th year.
- Irrigation treatments included:
  - Table based irrigation and P-M irrigation (daily values) for 10%, 20% nets and open plot. (6 treatments).
- We monitored climate, leaf temperatures, sap flow, yield and yield properties. Also soil and leaf salinity.

Zemach research station in a hot inner valley in Northern Israel

Based on lysimeter trials (20 years ago)
And previous P-M model (10 years ago)

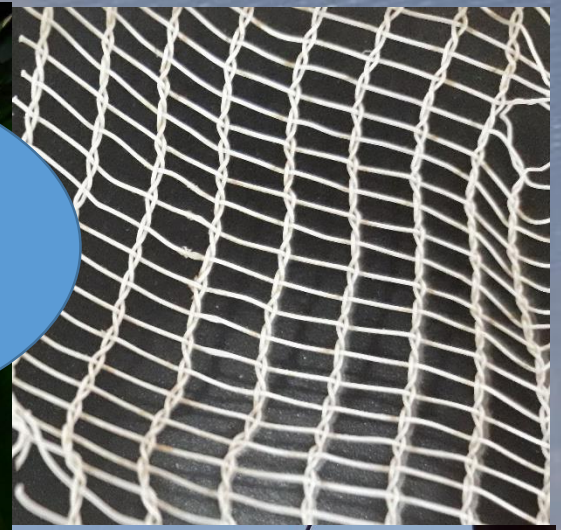


Planting in 2015

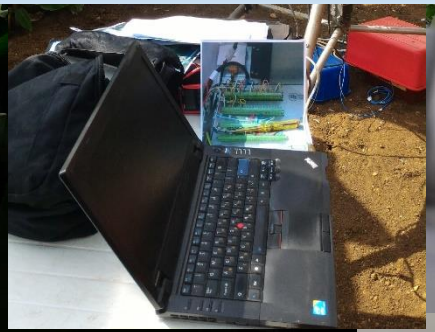


P-M equation solved in the datalogger after quality control

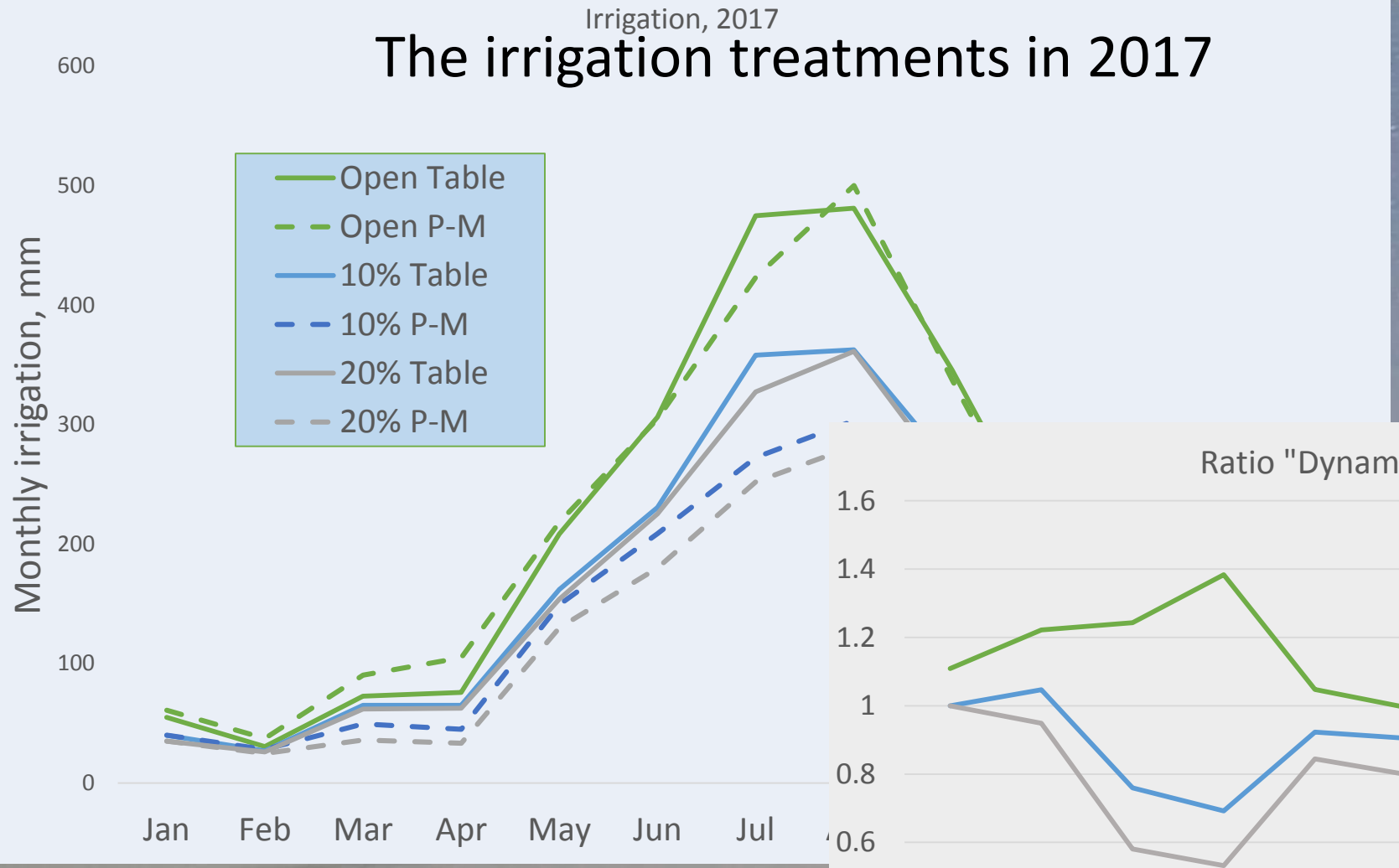
Data transmitted automatically via cellphone modem to shared Dropbox folder

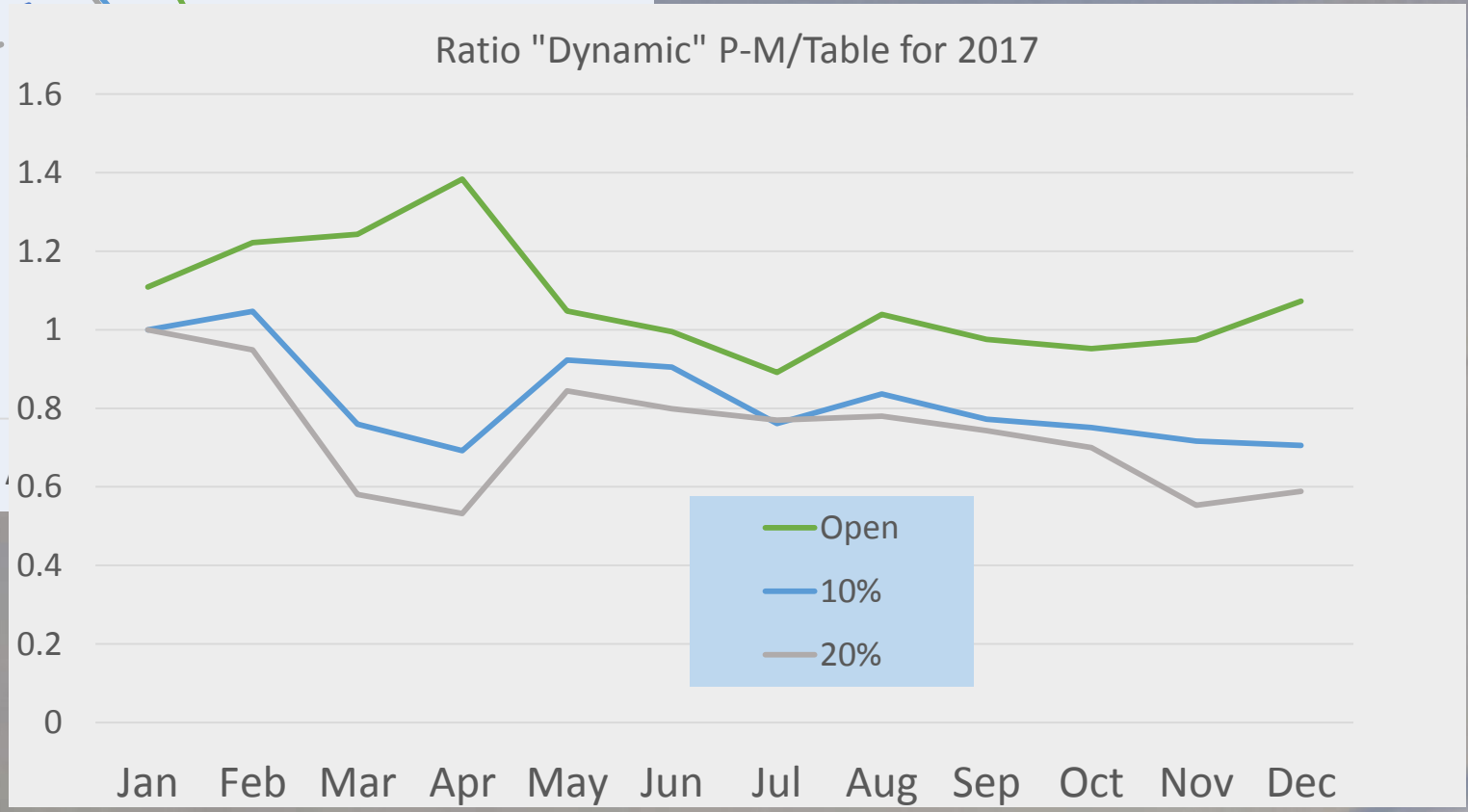


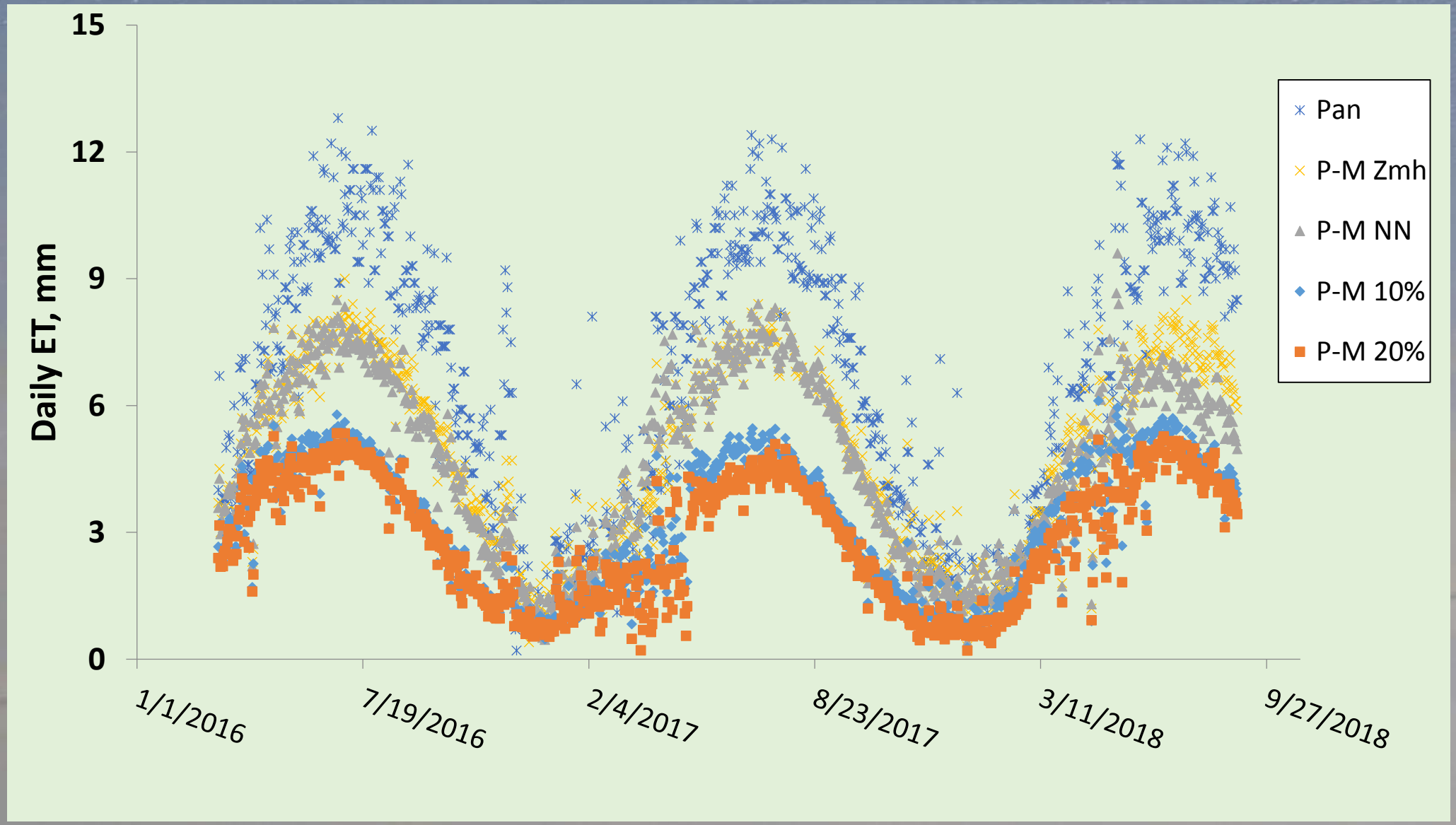
Irrigation set daily according to yesterday's P-M ET

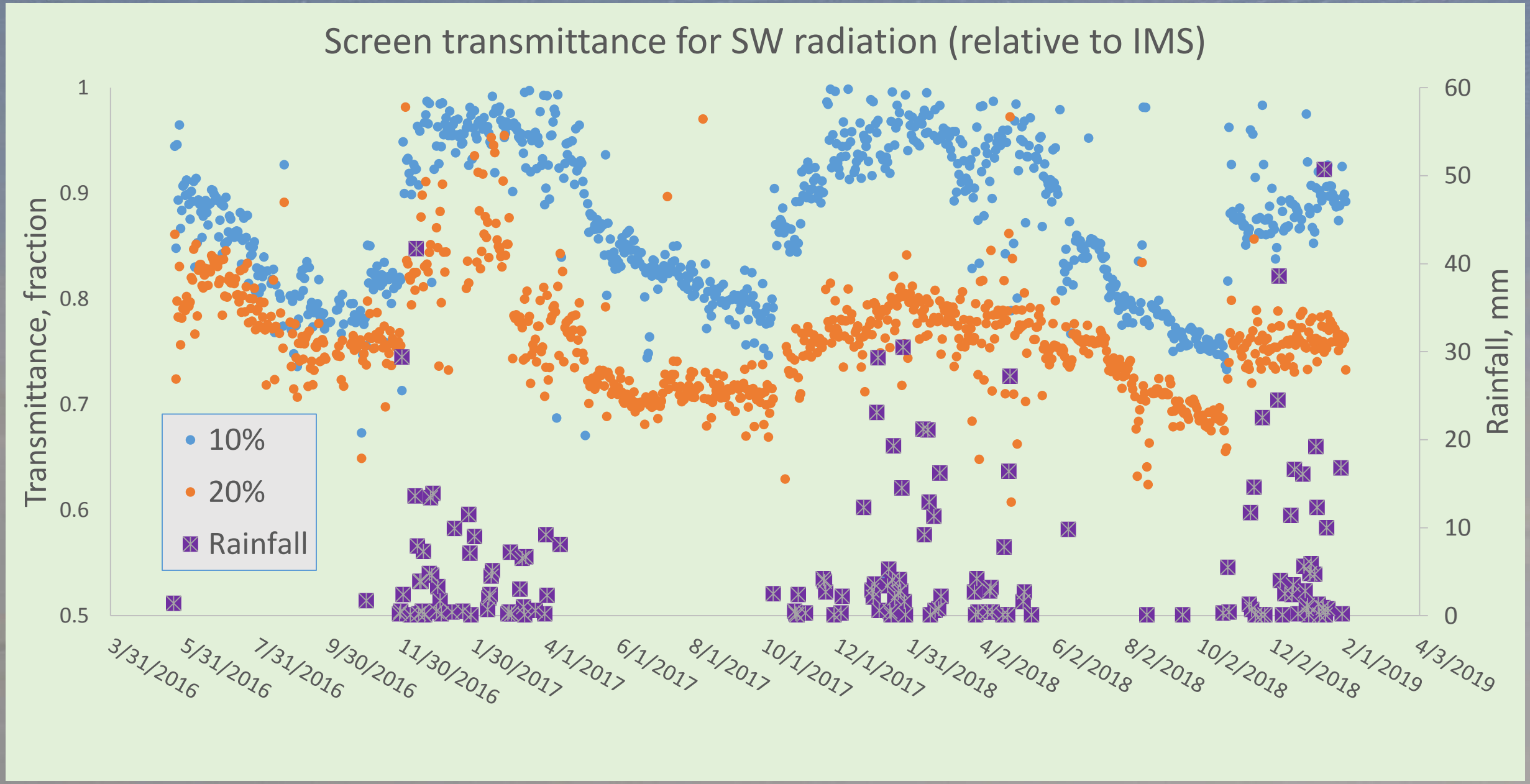


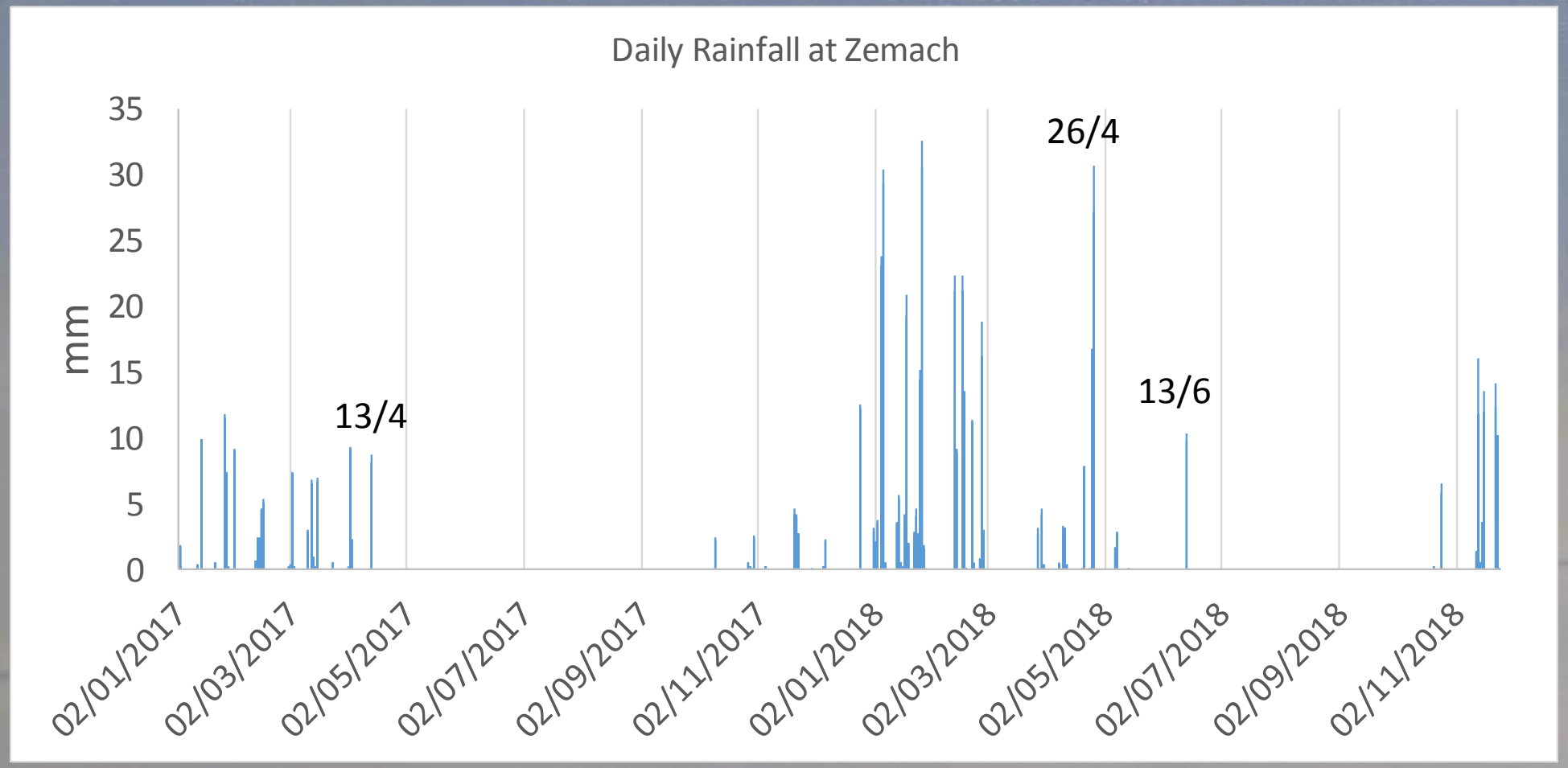
The irrigation treatments in 2017



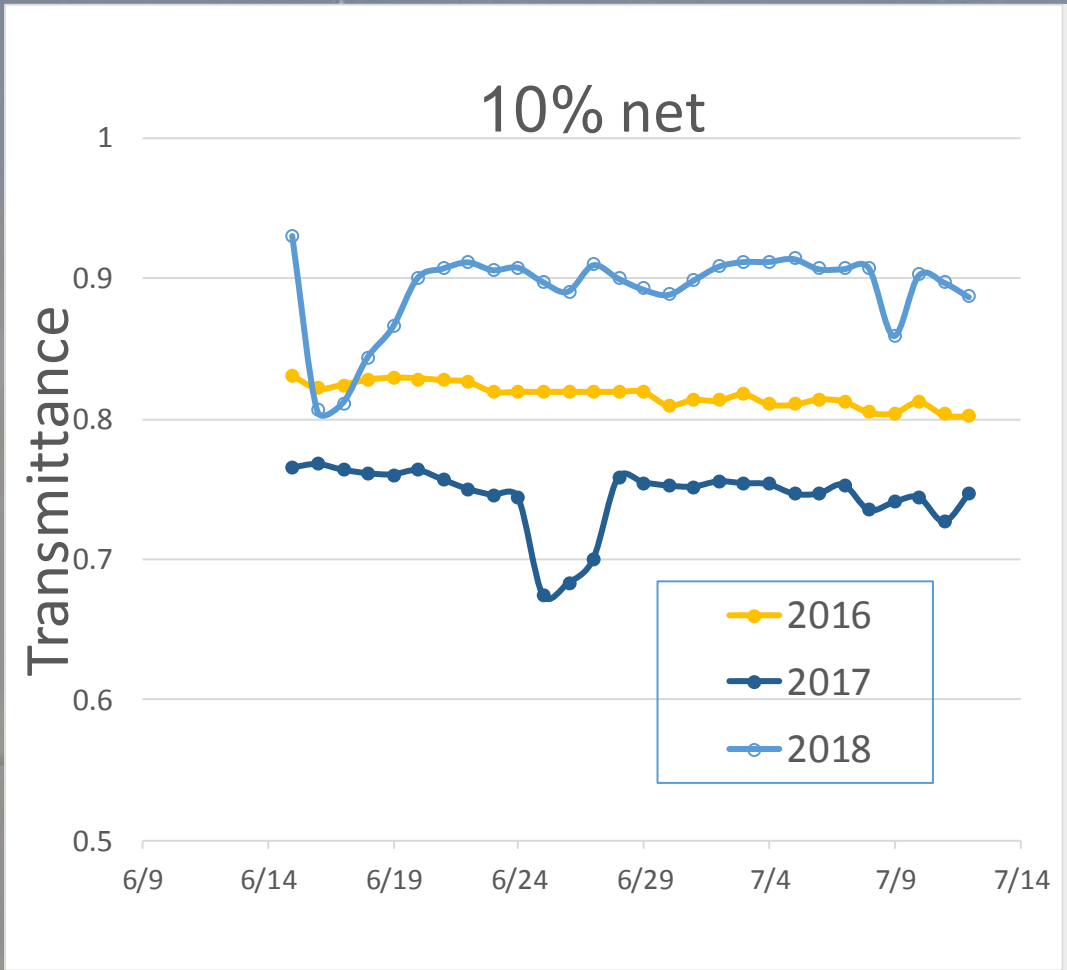


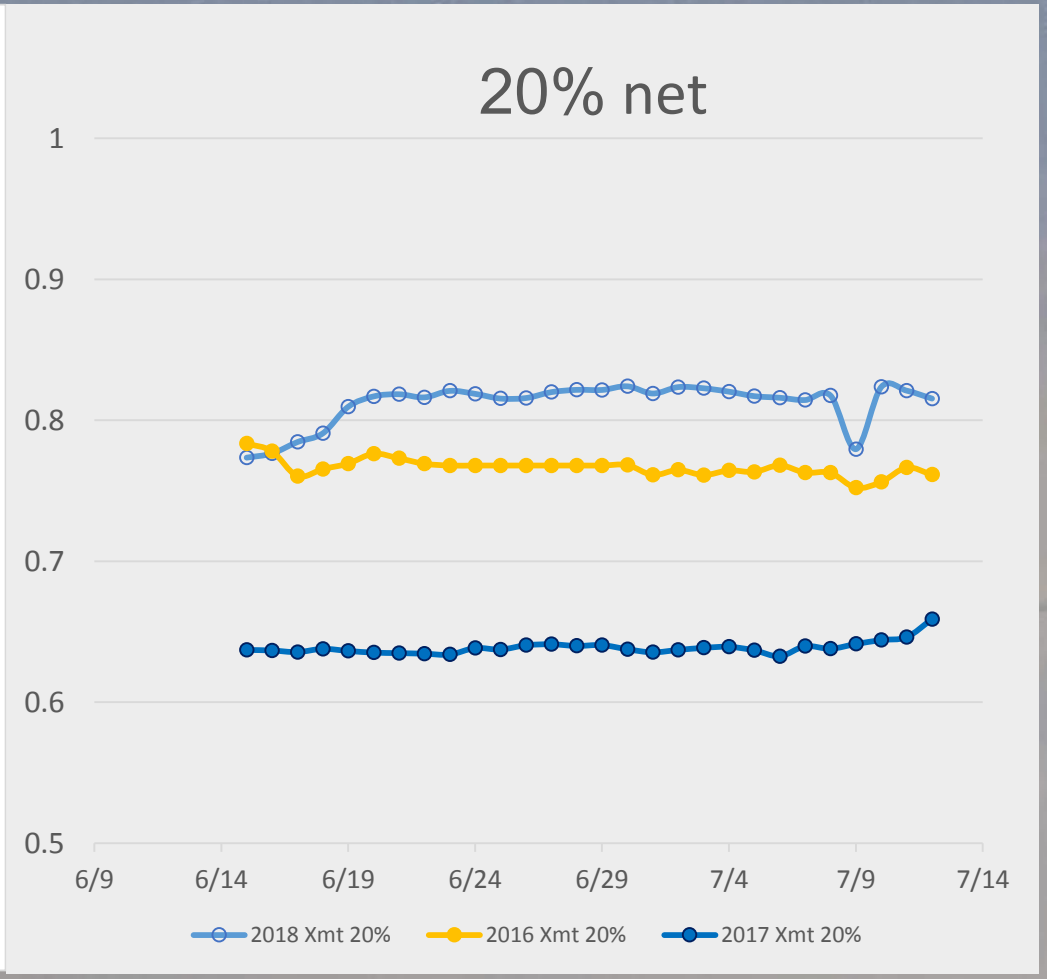

Daily ET, mm
15
12
9
6
3
0
1/1/2016
7/19/2016
2/4/2017
8/23/2017
3/11/2018
9/27/2018
Pan
P-M Zmh
P-M NN
P-M 10%
P-M 20%


Screen transmittance for SW radiation (relative to IMS)
Transmittance, fraction
Rainfall, mm
1
0.9
0.8
0.7
0.6
0.5
60
50
40
30
20
10
0
10%
20%
Rainfall
3/31/2016
5/31/2016
7/31/2016
9/30/2016
11/30/2016
1/30/2017
4/1/2017
6/1/2017
8/1/2017
10/1/2017
12/1/2017
1/31/2018
4/2/2018
6/2/2018
8/2/2018
10/2/2018
12/2/2018
2/1/2019
4/3/2019


Daily Rainfall at Zemach
mm
35
30
25
20
15
10
5
0
13/4
26/4
13/6
02/01/2017
02/03/2017
02/05/2017
02/07/2017
02/09/2017
02/11/2017
02/01/2018
02/03/2018
02/05/2018
02/07/2018
02/09/2018
02/11/2018

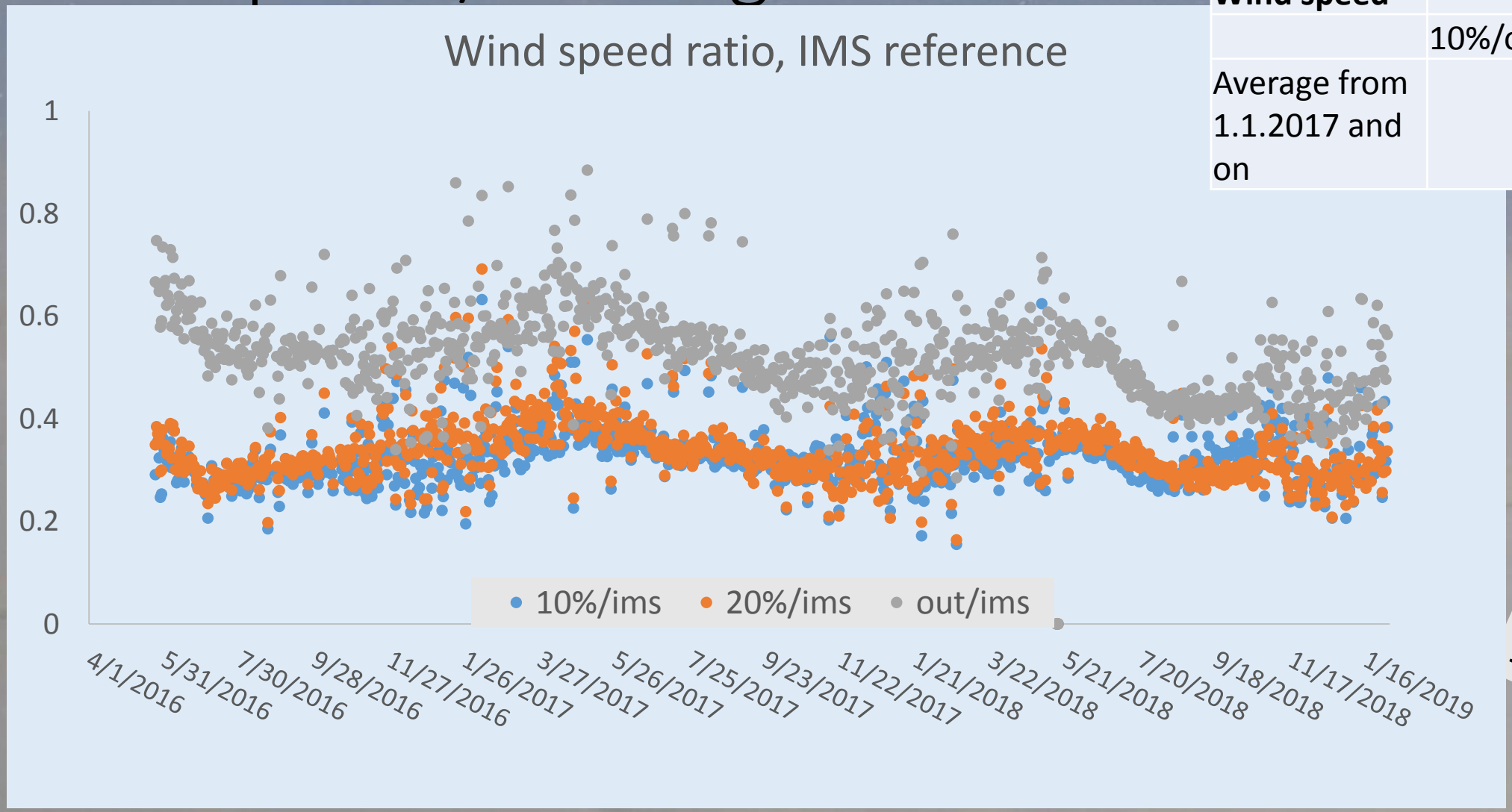
Dust accumulation/net transmittance is different each year… showing June-July values





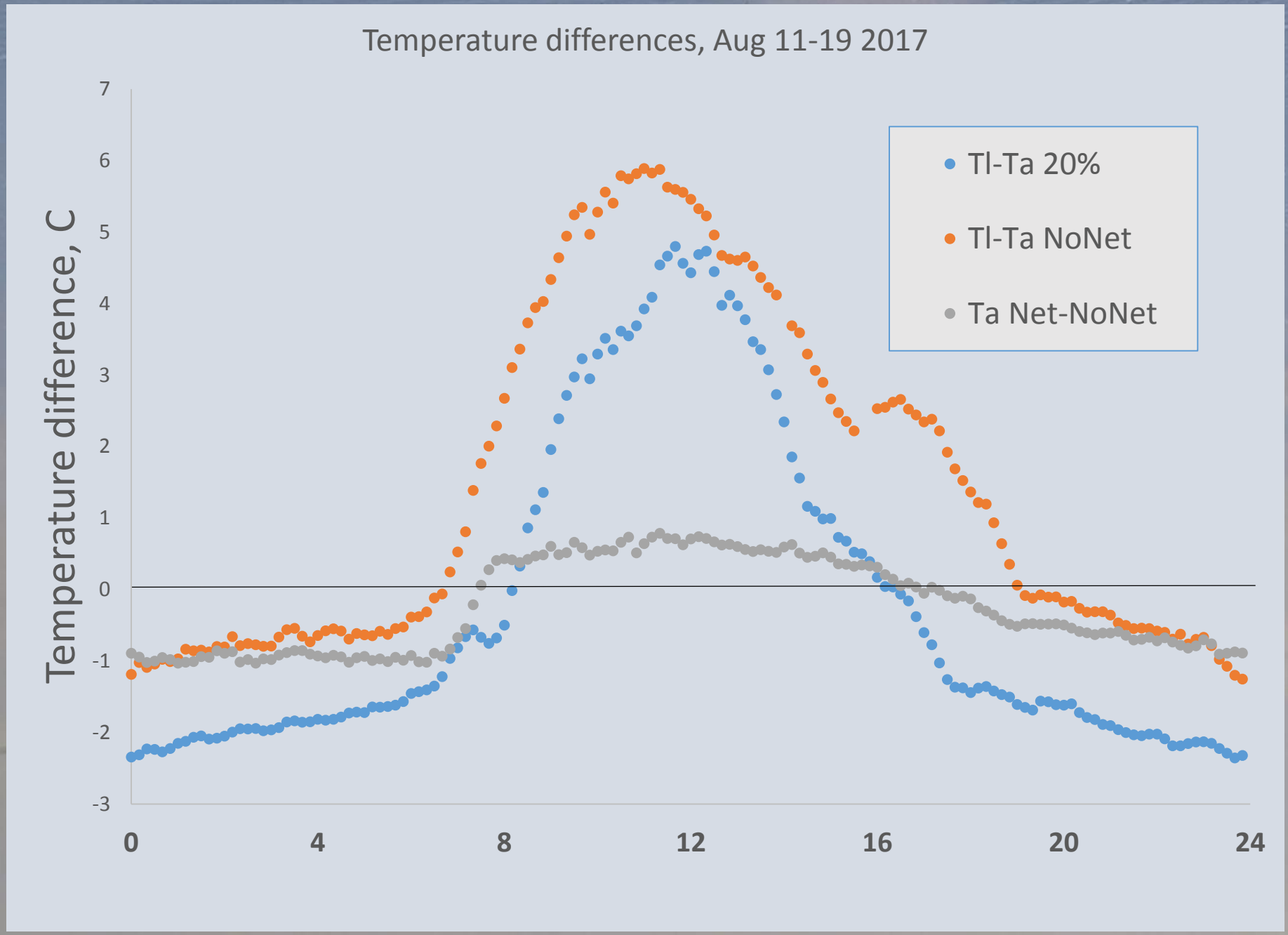
Wind speed in the net house also changes as the plants/leaves grow

Wind speed		
	10%/out	20%/out
Average from 1.1.2017 and on	62.3%	64.9%

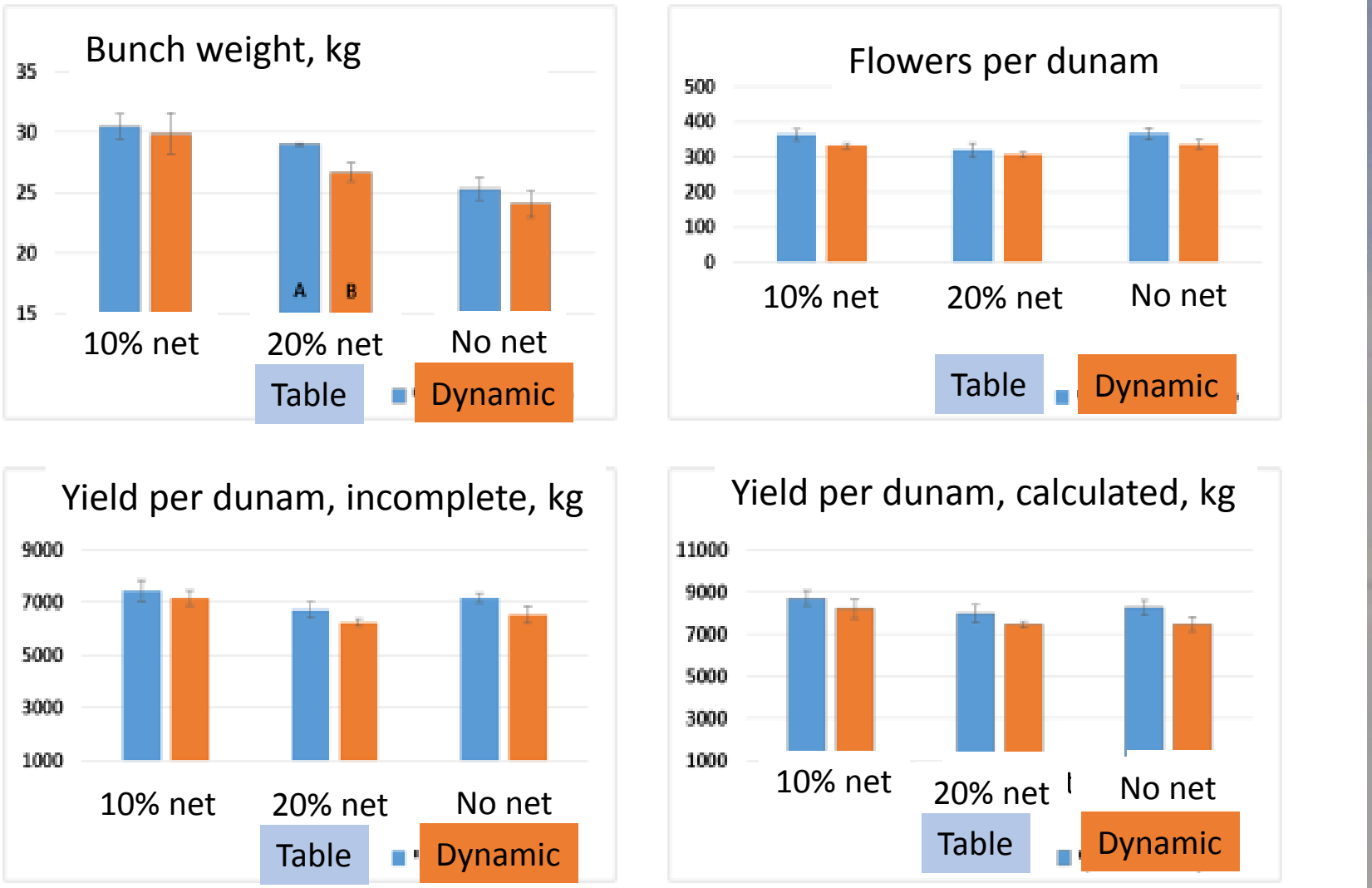


IMS- Israel Meteorological Service station at Zemach

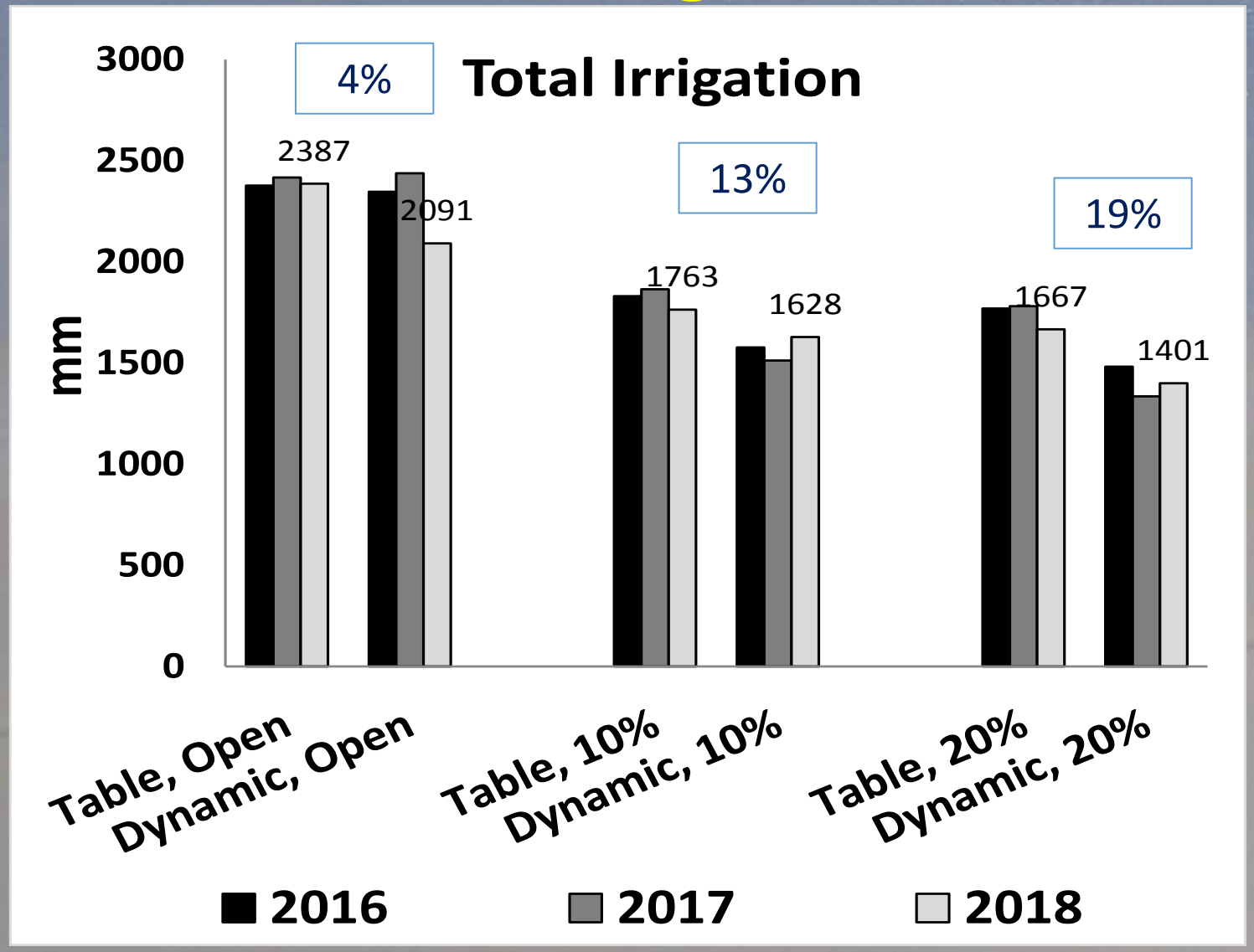
Leaf temperatures were measured with thermocouples inside hypodermic needles



The bottom line – yield and flowering, 2017/18
(note that each net was one house)

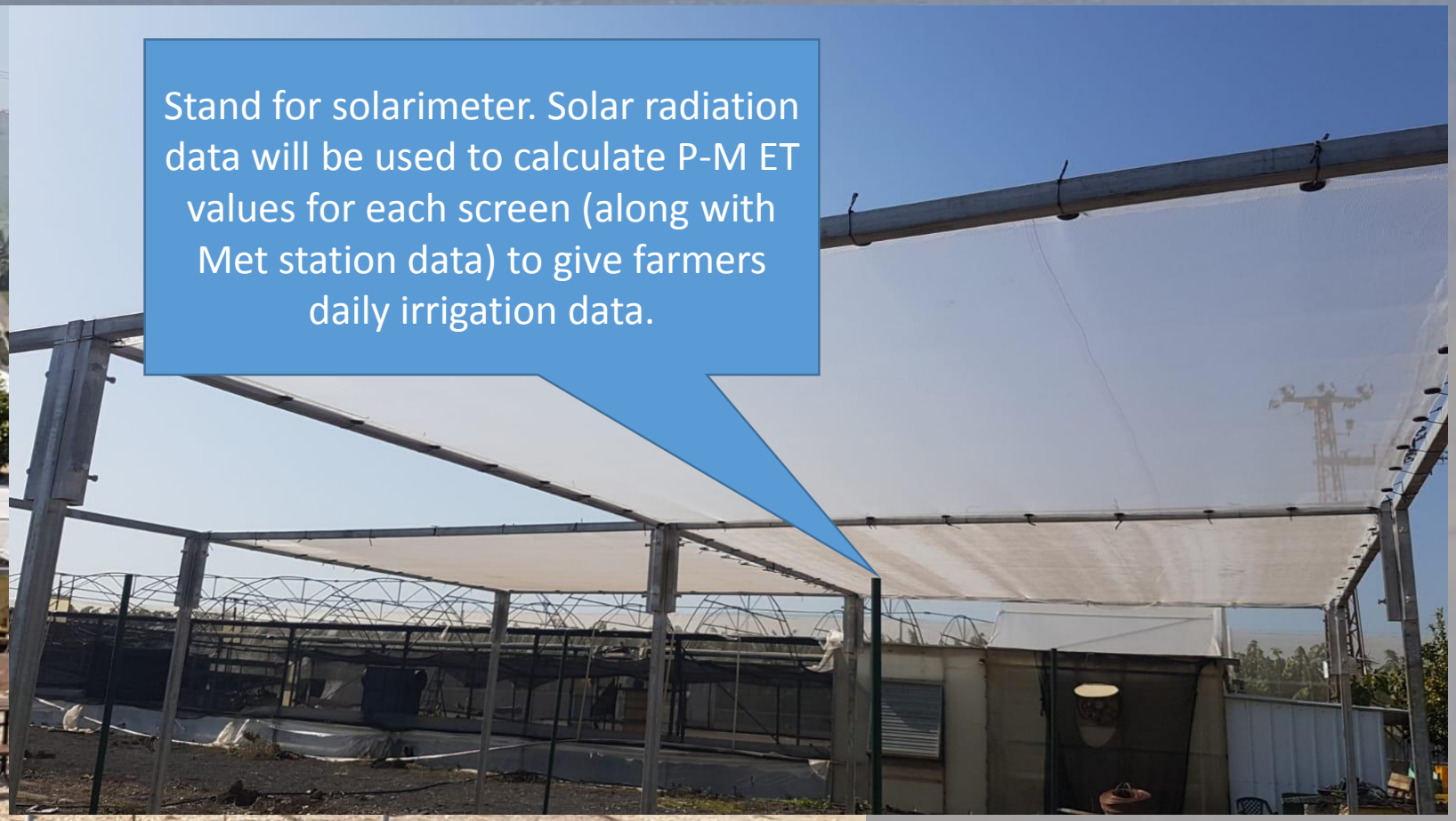


The bottom line – Irrigation totals, 2016-18



As water prices are high, farmers are waiting for the platform for implementation

Implementation – 3 nets above radiometers at the research station (in preparation)



Stand for solarimeter. Solar radiation data will be used to calculate P-M ET values for each screen (along with Met station data) to give farmers daily irrigation data.

Summary

- We implemented daily calculations of irrigation requirements according to climate in the screenhouse and an appropriate Penman-Monteith equation adaptation.
- The parameter that must be monitored continuously is solar radiation in the screenhouse.
- A three year irrigation trial in the banana plantation showed that we can save 15% of irrigation this way, without a significant reduction in yield.
- We will implement these findings with an appropriate screen structure which will feed data into the existing Agrometerological network.

Thanks for your attention

and thanks to:
- Chief Scientist Fund of the Israeli Ministry of Agriculture